Space Network

Dick Schonbachler,
Mission Commitment Manager
Goddard Space Flight Center, Code 451
November 2001

Mission Commitment Office GSFC Code 451

The GSFC Customer Commitment Manager assigns a Mission Commitment Manager to work with the Project Manager and CSOC Customer Service Representative to develop the detailed operations requirements resulting in the PSLA, DMR and if necessary the PCD.

Head of Customer Commitment Office – Jon Walker

Code M Mission Commitment Manager – Ted Sobchak

Code S Mission Commitment Manager – Leslie Ambrose

Code Y Mission Commitment Manager – Steve Kremer

Reimbursable Mission Commitment Manager – Jim Bangerter

SP&M Mission Commitment Manager – Dick Schonbachler

SN Resources

Mission Services Customer Forum

Tracking and Data Relay Satellites

First Generation TDRS
F-1 through F-7

Second Generation TDRS
F-8 through F-10

Tracking and Data Relay Satellite (F1 - F7)

Solar array
Power output is approximately 1800 watts

Omni Antenna (S-band) and Solar Sail

Single Access Antenna
Dual frequency communications
    and tracking functions:
        S-band TDRSS (SSA)
        K-band TDRSS (KSA)
        K-band auto-tracking
4.9 meter shaped reflector assembly
SA equipment compartment
    mounted behind reflector
Two axis gimballing

Space-to-Ground-Link Antenna
TDRS downlink
2.0 meter parabolic reflector
Dual orthogonal linear polarization TDRS:
    single horn feed
    orthomode transducer
Two axis gimballed

Multiple Access Antenna
30 helices:
    12 diplexers for transmit
    30 receive body mounted
Single commanded beam, transmit
20 adapted beams for receive
Ground implemented receive function

Tracking and Data Relay Satellite (H, I, J)

Multiple Access Antenna
On board MA return beamforming
6 beams

MA Array

SA Antenna - West

Forward TT&C Antenna
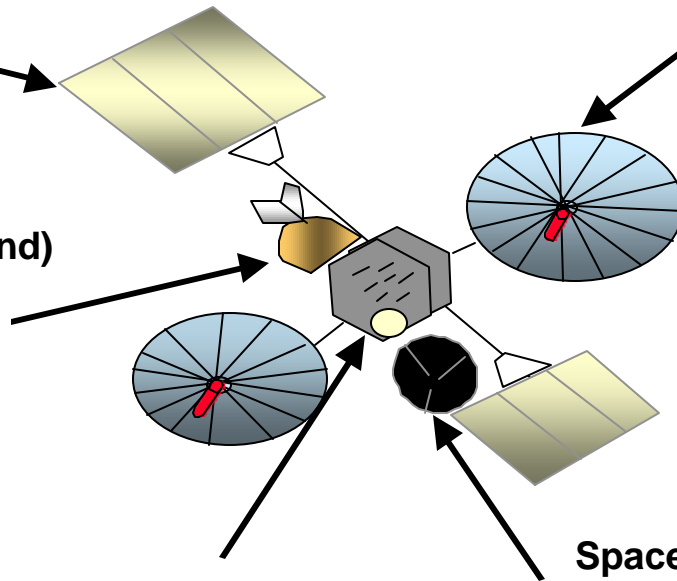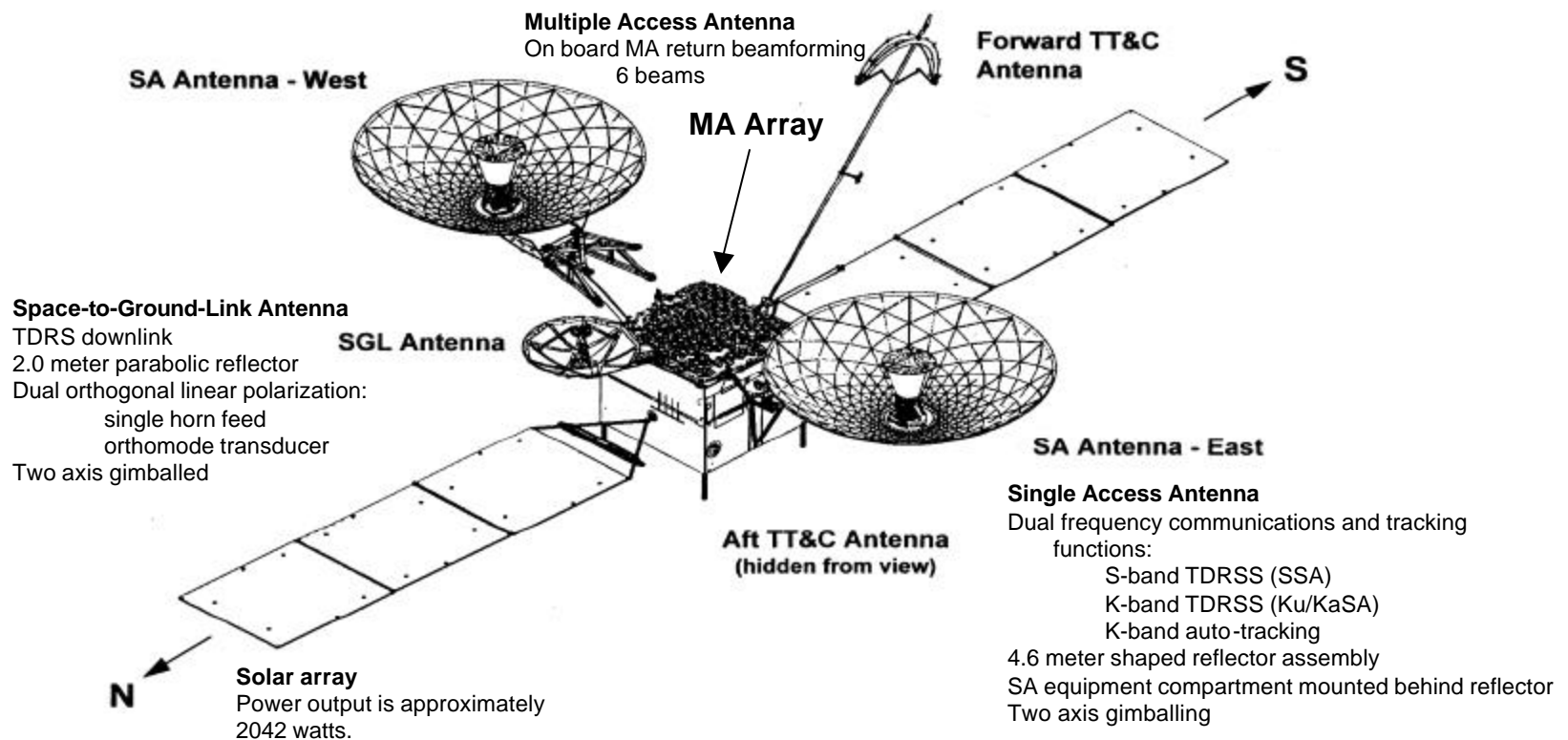
S

Space-to-Ground-Link Antenna
TDRS downlink
2.0 meter parabolic reflector
Dual orthogonal linear polarization:
        single horn feed
        orthomode transducer
Two axis gimballed

SGL Antenna

SA Antenna - East

Single Access Antenna
Dual frequency communications and tracking
        functions:
                S-band TDRSS (SSA)
                K-band TDRSS (Ku/KaSA)
                K-band auto-tracking
4.6 meter shaped reflector assembly
SA equipment compartment mounted behind reflector
Two axis gimballing

Aft TT&C Antenna
(hidden from view)

N

Solar array
Power output is approximately
2042 watts.

Mission Services Customer Forum

G S F C

Service Summary/System Capacity

	FREQUENCY	SERVICE	MAX. DATA RATE	SERVICES PER TDRS [1]	WSC [4] CAPABILITY	GUAM CAPABILITY
SINGLE ACCESS S BAND	2020.4 MHz - 2123.3 MHz	FORWARD	300 kbps	2	10	2
	2200 MHz - 2300 MHz	RETURN	6 Mbps	2	10	2
Ku BAND	13.747 GHz - 13.802 GHz	FORWARD	25 Mbps	2	10 [2]	2
	14.887 GHz - 15.119 GHz	RETURN	300 Mbps	2	10 [2]	2
Ka BAND	22.55 GHz 23.55 GHz	FORWARD	25 Mbps	2	6 [2]	0
	25.25 GHz 27.50 GHz	RETURN	300 Mbps 800 Mbps	2 1	6 [2] 0 [3]	0
MULTIPLE ACCESS S-BAND (1-7)	2103.1 MHz - 2109.7 MHz	FORWARD	300 kbps	1	4	1
	2284.5 MHz - 2290.5 MHz	RETURN	150 kbps	5	20	2
SMA (H,I,J)	2284.5 MHz – 2290.5 MHz	RETURN	6 Mbps	6	18	0

Notes:
 1. Fully operational S/C

 2. Ku and Ka FWD/RTN Service is Shared on the TDRS/WSC SGL. Simultaneous Ku and Ka Service Is Not Possible

 3. Ka-Band (H,I,J) 800 Mbps is not supported on the Ground (WSC)

 4. 4 SGLTS at WSC are capable of supporting the H,I,J S/C. WSC Ka-Band and SMA capability reflect the 6/18 respectively because there are only 3 H,I,J S/C
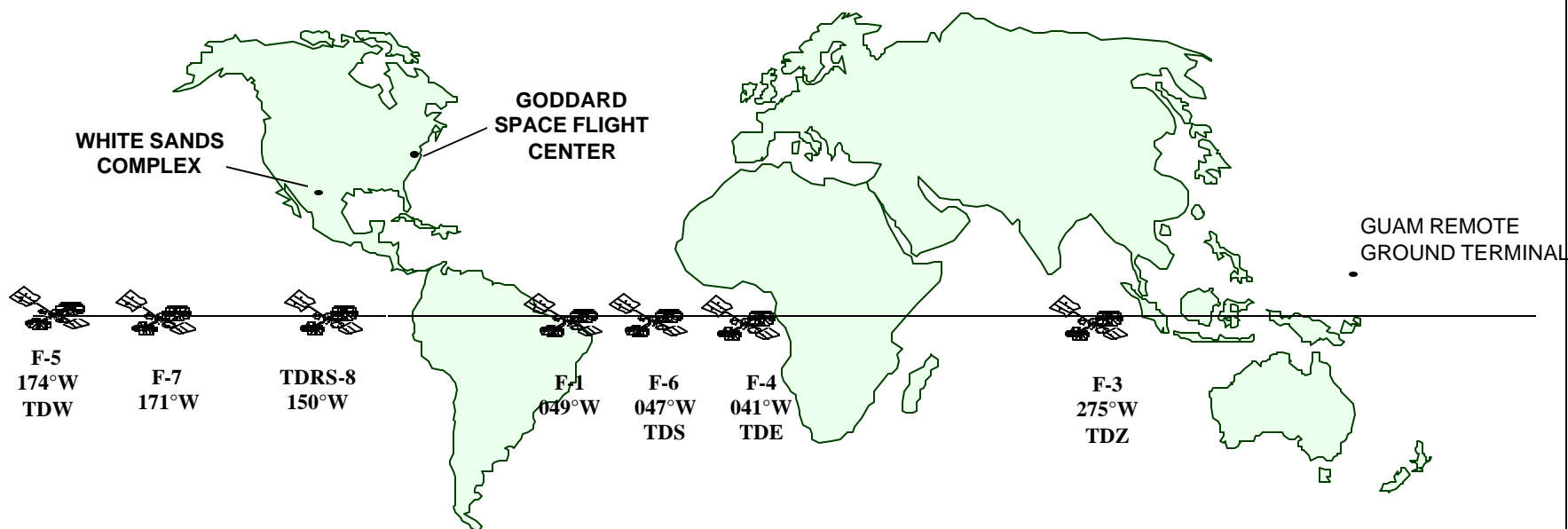

2 way ranging and 1 and 2 way Doppler tracking available

Mission Services Customer Forum

TDRS/TDRS H, I, J Service Comparison

SERVICE			TDRSS	TDRS - H,I,J	NOTES
SINGLE ACCESS	S-BAND	FWD	300 kbps	300 kbps	NO CHANGE
		RTN	6 Mbps	6 Mbps	
	Ku-BAND	FWD	25 Mbps	25 Mbps	
		RTN	300 Mbps	300 Mbps	
	Ka-BAND	FWD	N/A	25 Mbps	23/25-27 GHz frequency band
		RTN	N/A	800 Mbps	
	NUMBER OF LINKS PER SPACECRAFT		2 SSA 2 KuSA	2 SSA 2 KuSA 2 KaSA	FOR TDRS H,I,J SIMULTANEOUS OPERATION OF S & Ku AND S & Ka SERVICES A SINGLE SA ANTENNA ARE REQUIRED
MULTIPLE ACCESS	NUMBER OF LINKS PER S/C	FWD	1 @ 10 kbps	1 @ 10 kbps (8 dB over TDRSS)	ANTICIPATED SSA USERS LESS THAN 3 Mbps OFFLAOADED TO TDRS H,I,J MA
		RTN	5 @ 150 kbps LIMITED BY GROUND EQ. ONLY	6 @ 3 Mbps (ONBOARD BEAMFORMING)	
CUSTOMER TRACKING			150 meters 3 sigma	150 meters 3 sigma	NO CHANGE

Mission Services Customer Forum

Present TDRSS Constellation

WHITE SANDS
COMPLEX

GODDARD
SPACE FLIGHT
CENTER

GUAM REMOTE
GROUND TERMINAL

F-5
174°W
TDW

F-7
171°W

TDRS-8
150°W

F-1
049°W

F-6
047°W
TDS

**F-4**
041°W
TDE

F-3
275°W
TDZ

TDRS H,I,J Launch and Activation Plan

- TDRS H Launched 6/30/00
  - Accepted by NASA from Boeing Space Systems 10/17 /01
  - Will begin supporting customer operations TBD at the 171 degree west slot

- TDRS I Launch
  - NET 12/01

- TDRS J Launch 10/02

Mission Services Customer Forum

Candidate Option for Future Constellation
2002-2010

174⁰ 171⁰W 150⁰ W 79⁰ 62⁰ 49⁰ 47⁰ 41⁰ 275⁰ W
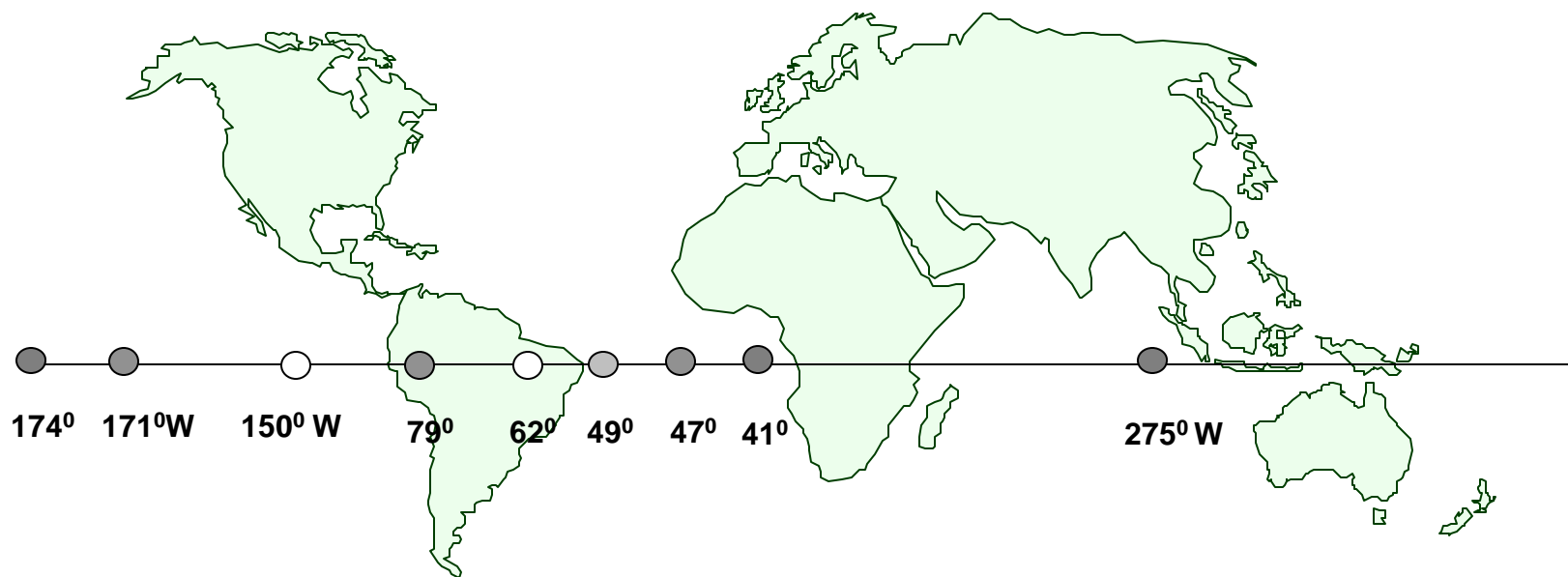
- ● **1st Generation TDRS**
- ● **2nd Generation TDRS**
- ○ **Open Slot**
- ◔ **NASA/NSF asset**

F10 ON-ORBIT STORAGE
(79W) NEEDED NET FY 2011

| TIMEFRAME	POTENTIAL OPERATIONAL TDRS LOCATIONS (DEGREES WEST)				
	41	47	171	174	275
2002 – 2005	F4	F6	F8	F7	F5
2006 – 2010	F6	F9	F8	F7	F5

Mission Services Customer Forum

Ground Segment

- TWO FUNCTIONALLY IDENTICAL, GEOGRAPHICALLY SEPARATED GROUND TERMINALS AT THE WHITE SANDS TEST FACILITY

- THE WSC HAS FIVE SPACE TO GROUND LINK TERMINALS (SGLTs)

- A SIXTH SGLT HAS BEEN INSTALLED AT THE REMOTE GROUND TERMINAL ON GUAM AS AN EXTENDED WSC SGLT

- NETWORK CONTROL CENTER

  - OPERATIONAL HUB LOCATED AT GODDARD SPACE FLIGHT CENTER FOR COORDINATING ALL SPACE NETWORK ACTIVITIES

Mission Services Customer Forum

Space Ground Link Terminal Configuration

Mission Services Customer Forum

G S F C
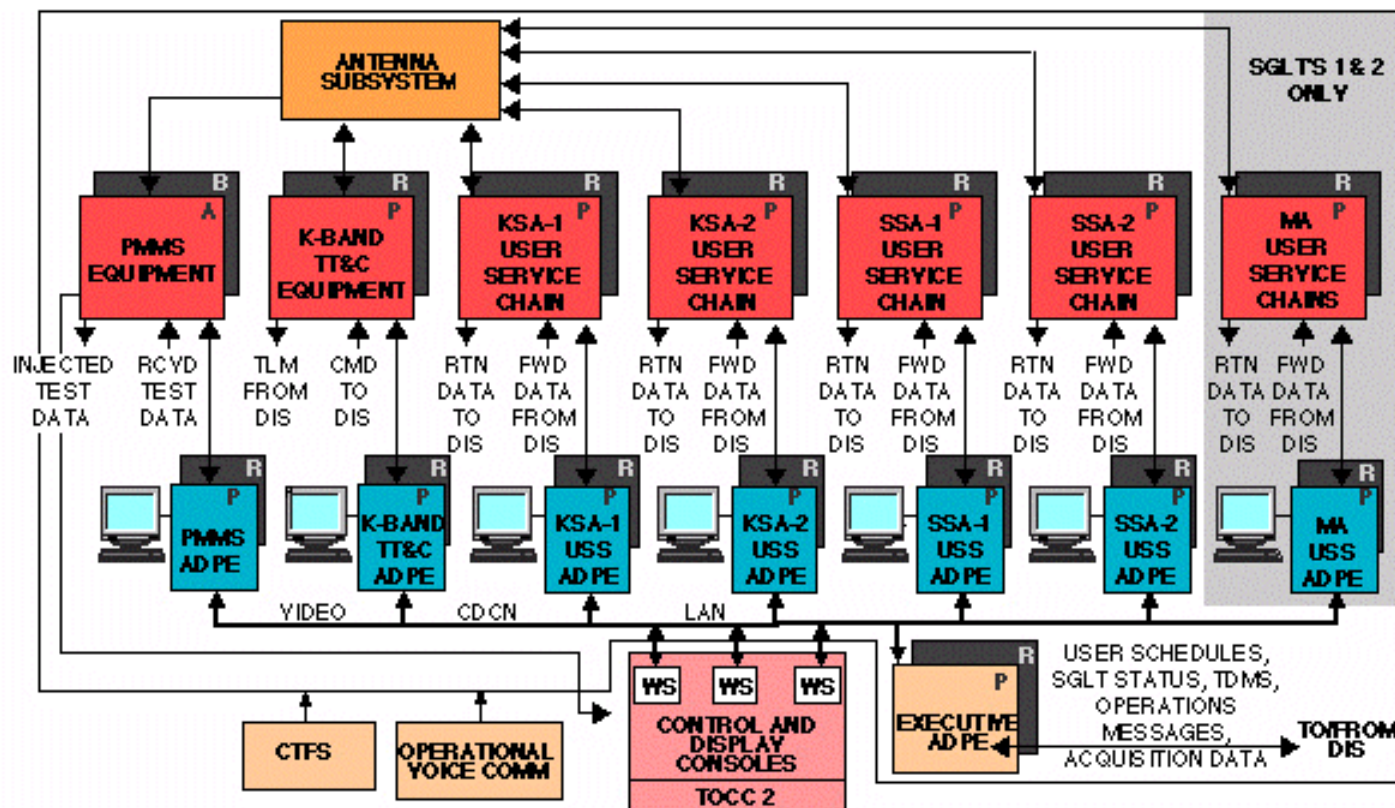
Operations

GROUND SEGMENT OPERATIONS

- CUSTOMER OPERATIONS

  – In Response to Scheduled Events, ground equipment is configured and operated automatically

  – Service is monitored by the Communications Services Controller (CSC) in the WSC TDRS Operations Control Center (TOCC). When anomalies occur most are handled automatically within the SGLT for minimum data loss

  – The CSC has a voice interface with the customer to handle/recommend actions for resolution of other anomalies

Mission Services Customer Forum

G S F C

Network Control Operations

- Service Planning
  - NCC Database Management
  - Automatic Conflict Resolution System (ACRS) used for Forward and Return Link Mutual Interference Prediction

- Scheduling
  - Forecast Period
  - Active Period
  - Conflict Resolution

- Mission Operations Support
  - Event Monitoring
  - Real Time Fault Isolation

Mission Services Customer Forum

G **S** F **C**

Space Network Proficiency
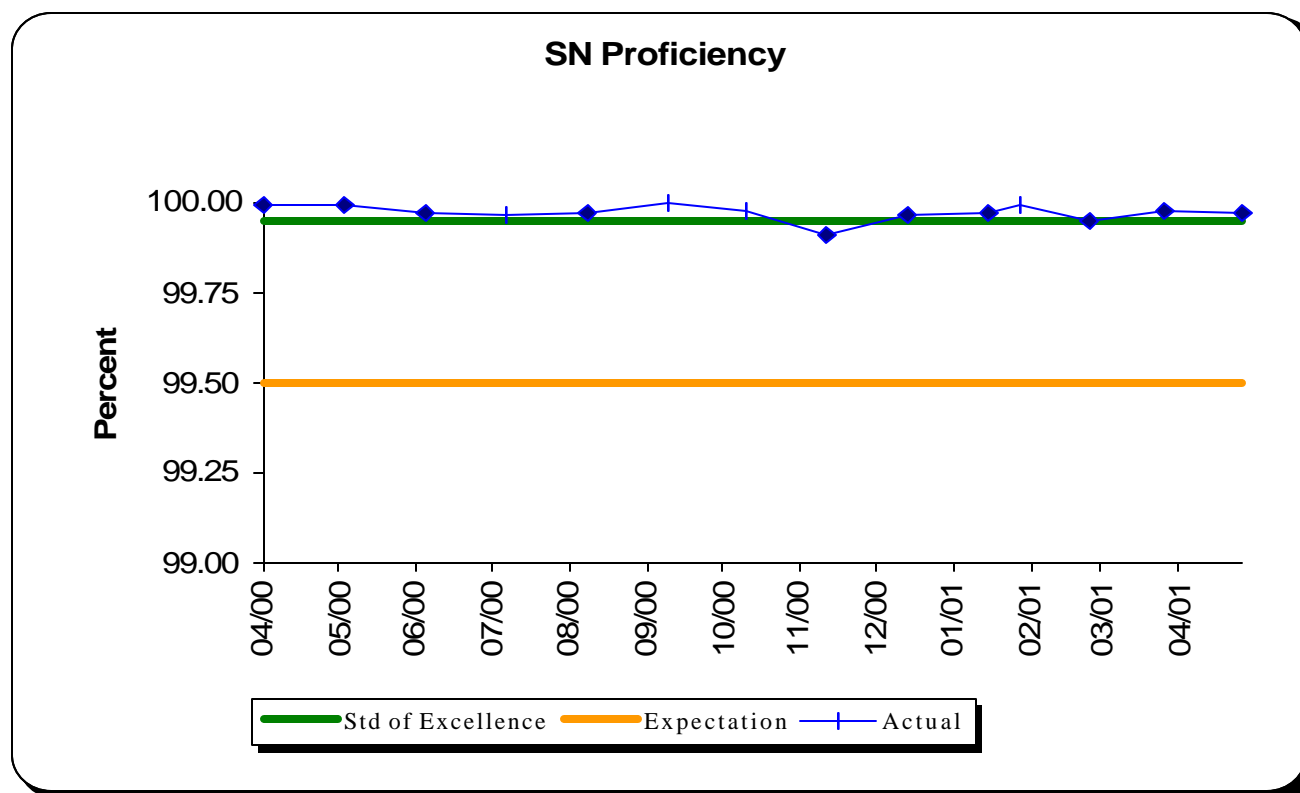
SN Proficiency

Legend: Std of Excellence — Expectation — Actual

Mission Support

Mission Services Customer Forum
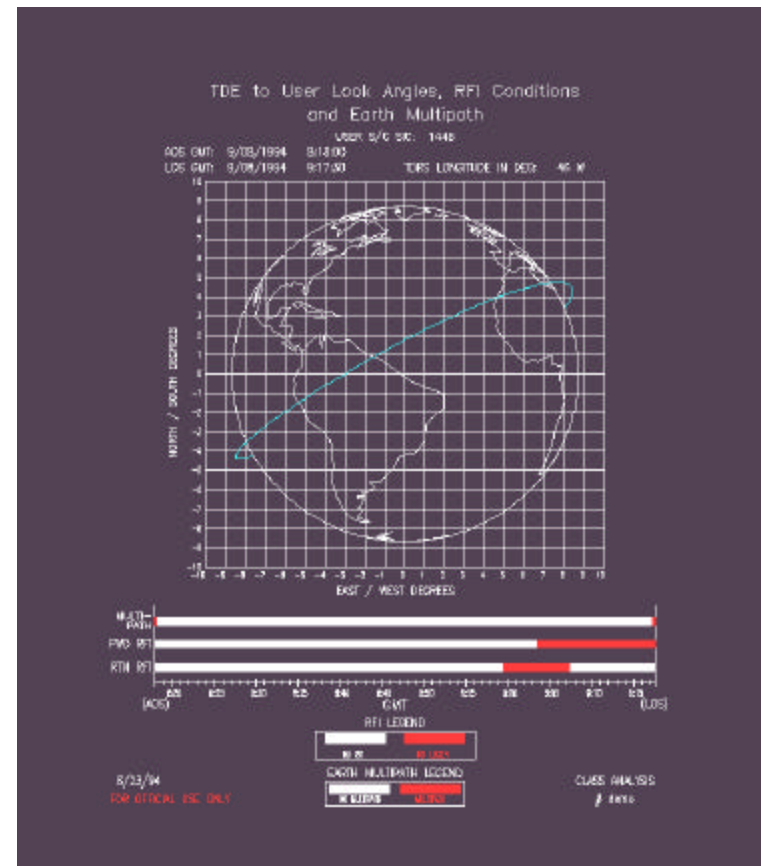
Pre-Mission Planning Services

- Mission Planning
  - Computer Link Analysis System (CLASS)
    - Static Link Margin Analysis
    - Dynamic Link Analysis of Actual trajectory/orbit to determine TDRS coverage periods

Compatibility Testing

- Operations Planning
  - Implementation of network enhancements to support evolving generic and unique customer requirements

- Testing
  - Provide characterization, IV&V and compatibility testing for mission readiness
  - Proficiency and abort simulations
  - Testing Resources
    - Compatibility Test Van
    - Direct Support via Pad or rooftop antenna
   - RF SOC

Mission Services Customer Forum

Expendable Launch Vehicle Support

- Proven Track Record for ELV support
- Provides advantages for receiving telemetry data as well as advantages to Project Control Centers
  - Expanded geometric coverage for critical events for flexible mission profiles
  - Eliminates costly methods of receiving telemetry
  - Almost no data latency
  - Variety of data rates, frequencies and modulation types can be supported

Mission Services Customer Forum

Global Coverage for Mark Events

Mission Services Customer Forum
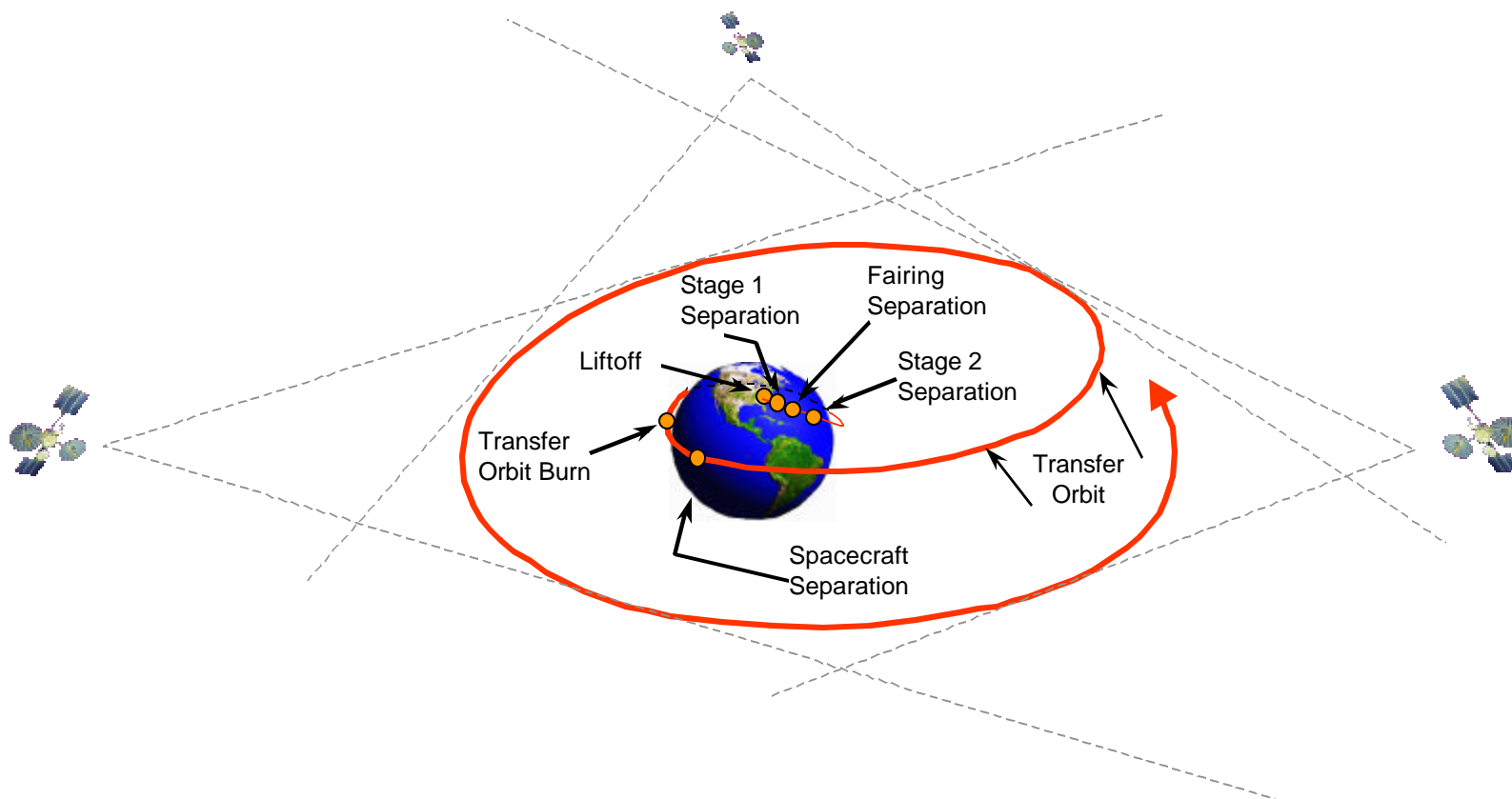
SN SUPPORT OF GN MODE OPERATIONS

- WSC HAS BEEN MODIFIED TO ALLOW COMMAND/TELEMETRY AND TRACKING SUPPORT FOR GN MODE S-BAND COMMUNICATIONS.

- SPACE LOSS ASSOCIATED WITH SN OPERATIONS ONLY ALLOWS GN MODE SUPPORT USING SSA SERVICE
    - TYPICALLY, 1 - 2 Kbps COMMAND
    - 8-16 Kbps TELEMETRY RATES ARE OBTAINABLE (USING OMNI ANTENNA)
        - Based on SN FUSE mission support

- TDRSS HAS SUPPORTED COMMAND, TELEMETRY AND TRACKING IN GN MODE FOR MANY PROJECTS AS SHOWN BELOW
    - COMMAND
        - ON-ORBIT – FUSE, EO-1
        - GROUND TEST – TIMED, MAP

    - TELEMETRY
        - ON-ORBIT – FUSE, EO-1, NOAA-16, GPS, TOMS/EP, LUNAR PROSPECTOR, ACRIMSAT, RADARSAT, HST(GN)
        - GROUND TEST – TIMED, MAP

    - TRACKING (ON-ORBIT)
        - 1 WAY – WIND, NOAA 14/15/16, POLAR, TOMS, EO-1, FUSE (LOF)
        - 2 WAY – EO-1

Technology

Mission Services Customer Forum

Web Based SN Services

- SN Web Services Interface (SWSI)

  – Available in March 2002

  – Provides SN service scheduling and real-time control of TDRSS services

  – NISN interfaces available for open and closed IONET

- WSC TCP/IP Data Interface Service Capability (WDISC)

  – Provides TCP/IP connectivity for TDRSS Command and Telemetry services

  – Data interface available to both open and closed IONET NISN circuits

  – WDISC schedules are currently submitted verbally or by Briefing Message to NCC. Minimum turnaround of 20 minutes to obtain services when requested verbally

Demand Access

- Demand Access Service (DAS)

  – Available April 2002

  – Provides MA return services for extended periods at relatively low cost

    • Annual Subscription fee vice per minute fee

  – MA forward not available

  – Uses TDRS 3 -7

  – Initial implementation provides 8 links at WSC and 8 at Guam

  – Expansion to modularly add links is inherent in DAS design

  – Scheduled and controlled via SWSI interface

  – TCP/IP based telemetry data provided via NISN open or closed IONet circuits

  – Several customers have baselined DAS for mission use (GLAST, Swift, EOS-Aqua, Agile' and others)

Fourth Generation Transponder

- TDRSS/GN Compatible
- Low Power Consumption
  - 6 Watts for Receiver
  - 34 Watts for Rx/Tx (w/5 Watt transmitter output)
- Lightweight – 8 lbs.
- Small Profile 8"L X 6.3"W X 5.2" H
- Ku-Band Transmitter Exciter Option
  - Adds 1lb and 5 Watts power consumption
  - Motorola has 14 units on order
  - Gravity Probe (2), X-38 (2), National Scientific Balloon Facility (4), EOS-PM (2), EOS Chem (2), SWIFT (2)
  - Cost ≈ 1.1 Mil

Fourth Generation
TDRSS/GN Compatible

Transponder

The Fourth Generation TDRSS User Transponder (TDRSS 4), developed by Motorola for NASA's Goddard Space Flight Center, provides a spacecraft terminal for S-Band and K$_u$-Band telecommunications via the NASA Tracking and Data Relay Satellite System (TDRSS). Making extensive use of MMIC's and signal-processing ASIC, the design offers significant savings in size, weight, power and cost over previous-generation designs. Also compatible with NASA's ground tracking network (GN), the unit offers MIL-STD-1773/1553 bus interface and K$_u$-Band return link capability as options.

"S-Band Only" Configuration with MIL-STD-1553 Interface

With K$_u$ Transmitter Option and MIL-STD-1773 Optical Interface

Low Power Transceiver

- TDRSS/GN Compatible
  - Integrated 12 channel receiver for SN/GN/GPS
  - Tx power options from 1 Watt to 25 Watts
- Low power consumption
  - 8 Watts for Receiver
  - 11 Watts with 1 Watt HPA
- Lightweight – 6.7 lbs.
- Low Profile – 4.68" X 5.33" X 4.25"
- Being considered for ELV/EELV Range Safety application and On-Orbit Spacecraft
- Will fly aboard STS-107 (6/2002) as a Hitchhiker experiment for Proof-of-Concept and qualification
- Cost $\approx$ 300K – 400K

Multimode S-Band NASA/GN Transceiver (MMT)

- TDRSS/GN Compatible

- Low Power Consumption
  - 6 Watts for Receiver
  - Transmitter options under development

- Being considered for On-Orbit and Slow moving ground based applications

- Motorola has 18 MMTs on order
  - X-37 (8)
  - National Scientific Balloon Facility (9)
  - C/NOFS (1) COMM/NAV Outage Forecasting System (AFRL)
  - Cost ≈ 300 K – 400 K

Mission Services Customer Forum

Resources

- TDRSS Online Information Center
    - A comprehensive online resource with current and detailed information on all aspects of TDRSS and the Space Network
    - This presentation can be found contained in this website
    - http://msp.gsfc.nasa.gov/tdrss/

- Document and Data Control System Online Library
    - A website that provides easy access to MSPO technical documentation
    - http://csoc-ddcs.csoconline.com/library/

Backup

McMurdo/TDRSS Relay System

- McMurdo/TDRSS Relay System
  - Two K-band relay sites will be accessible to the GN McMurdo Ground Station in Antarctica
  - Capable of Near Real-Time telemetry throughput from MGS to WSC via TDRS 171W/174W
  - Data Rates up to 150 MBPS can be supported
  - WSC has data interface into EDOS/EBNET for data transfer to GSFC for EOS MOCs

ELV Support

Current ELV Customers

- TITAN/CENTAUR (MAY 94)
  - 128 KB
- ATLAS/CENTAUR (JAN 96)
  - 512 KB
- SEALAUNCH (MARCH 99)
  - 512 KB
- ATLAS III (MAY 00)
  - 256 KB/200 KB (I/Q)
- NAVY P3 RELAY
- TITAN –16 KB
- DELTA II (2ND STAGE) – 17 KB
- DELTA II (3RD STAGE) – 9.6 KB
- PEGASUS – 116KB
- IUS – 64 KB

Future ELV Customers

- DELTA IV (EELV)
  - 192 KB
- ARIANE V (ATV MISSION FOR ESA)
  - 250 KB
- H-IIA (NASDA)
  - 131 KB
- KISTLER AEROSPACE (REUSABLE)
  - 100 KB
- ATLAS V (EELV)
  - UNKNOWN (ANTICIPATED SAME AS ATLAS III)

Mission Services Customer Forum

G **S** F C

DAS Reference Architecture

WSGT/STGT

GRGT

DAS

EMC

EMC Data Routing Switch

Administration Interfaces

EMC

Switching — Control/Status

Resource Allocation Accounting

Control/Status — Beamforming

Beamforming — Control/Status

Control/Status — Switching

Switching — Control/Status

Control/Status

Control/Status — Demodulating

Demodulating — Control/Status

Hub

Hub

DAS Control

GDIS

Hub

Data Archiving, Routing, & Retrieval

Control/Status

Request/Status

Control/Status

Data Archiving, Routing, & Retrieval

Hub

Telemetry

Telemetry

Hub

Telemetry

Telemetry

Telemetry

Dedicated Customer Circuit Interfaces

Telemetry

Dedicated Customer Circuit Interfaces

Telemetry

Closed IOnet

DAS Customers

SWSI

Control/Status/Requests

NISN Secure Gateway

Control/Status/Requests

DAS Customers

SWSI

OPEN IOnet

Telemetry

Key

Telemetry

Control/Status/ Service Requests